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THE EFFECT OF RIVER FLOW ON ABUNDANCE OF PRE-SMOLT FALL CHINOOK SALMON IN THE NORTH LEWIS RIVER BELOW MERWIN DAM, 1978-80 AND 1983-85

PROGRESS REPORT 87-15

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INTRODUCTION

The North Lewis River below Merwin Dam supports a large population of fall chinook salmon, averaging 12,500 spawners from 1964-86 (Norman, 1987). This population is pre-dominantly naturally produced, with negligible in-stream releases of hatchery produced fall chinook in the last fifty-five years (Table 1). River flow downstream from Merwin Dam, averaging 4900 cfs during 1926-1981, is essentially a function of water releases from Merwin Dam, as no substantial (summer low flows averaging > 10 cfs) tributaries enter the North Fork below that site.

The relationship between river flow and juvenile fall chinook abundance is of management interest because of the potential for control of water released from upstream reservoirs (Figure 1). Article 49 of the Merwin Dam operation license, granted to Pacific Power and Light Company (PP&L) by the Federal Energy Regulatory Commission (FERC), states that mitigation for fall chinook losses due to hydro power development will occur through enhancement of the existing population below Merwin Dam with river flow control. A study following the instream flow incremental methodology (IFIM) indicated low flows (600-1400 cfs) would maximize habitat usable by fall chinook juveniles (Leder and Neuner, 1984). A relationship between flow and juvenile fall chinook salmon abundance is also of interest in measuring impacts of further development in the basin, such as construction of the major trout hatchery that is currently in the planning stage.

The purpose of this paper is: (1) to present juvenile fall chinook population estimates for the years 1978-80 and 1983-85 and, (2) to explore the relationship between river flow and these juvenile chinook populations.

METHODS

Population Estimates

Juvenile fall chinook salmon in the North Lewis River have been tagged with coded wire tags (CWT) during the spring and summer months of 1978-80 as part of an overall evaluation of the resident stock (McIsaac 1979, 1980, and 1981). Annually beginning 1983, juvenile chinook have been tagged during June for harvest management indexing purposes (Norman 1984, 1985a, 1986, and Roler 1987). Date of tagging, codes used, and numbers tagged for these years are shown in Table 2. Recapture of CWT fish occurs in all major fisheries, as well as on the natural spawning grounds.

McIsaac (1987) evaluated four mark-recapture methodologies for use in producing a juvenile population estimate in the North Lewis River for rearing year 1980. The following model appeared to be the most usable of those examined, and was used in this analysis.

$$N = \frac{M}{S}$$

where

N = Juvenile fall chinook population

M = Number of mature spawners

S = Survival rate of representative CWT groups to the spawning stage

Better comparability of population estimates between years was accomplished by only using CWT groups with individual fish that were captured, tagged, and released within 48 hours, and also confined to the late May through June time frame. Table 3 details the groups actually used, which comprised annual total numbers tagged ranging from 35,866 - 103,796.

Numbers of spawning fish by brood year used in the analysis are listed in Table 4. Recoveries of CWT from the spawning grounds and estimated total return of CWT fish based on proportion of the spawning population sampled are shown in Table 5.

Final pre-smolt population estimates occur about five and one half years after tagging, as this salmon stock returns at ages 2-6. However, preliminary pre-smolt population estimates can be produced after the first return of mature fish at age 2. Preliminary pre-smolt population estimates were used in this analysis for rearing years 1983-85.

River Flow Relationships

Daily river flow, as measured by discharge at Merwin Dam, was provided by PP&L and is listed in Appendix 1 and graphically illustrated in Figures 1A through 12A. Pre-smolt population estimates were regressed against various flow parameters using both single and multiple linear regression techniques (Draper and Smith, 1966). Flow parameters examined were limited to the rearing months of April through July for the single regression analysis. In general, wet and dry year characteristics were examined, such as number of days at low flows, and number of days at high flows, average monthly flows, and total seasonal flow. Individual monthly flow characteristics were examined to expose any critical periods. A total of 69 regressions were examined, using flow indices from less than 1000 cfs to greater than 7000 cfs. Multiple linear regression analysis used from two to four uncorrelated variables.

RESULTS

Population Estimates

Pre-smolt population estimates ranged from a low of 2,390,000 in 1978 to a high of 6,440,000 in 1984 and averaged 3,900,000. The three estimates for 1978-80 are at a lower level than the three estimates for 1983-85, with averages of 2,780,000 and 5,000,000 respectively (Table 6). Appendix 2 details a worksheet used to calculate the annual population estimates.

River Flow Relationships

Table 7 lists input data and r^2 values for single regressions that are graphically shown in Figures 2 through 27. Table 8 details variables and r^2 values for single regressions not associated with figures. Table 9 lists variables and r^2 values for multiple regressions examined.

There did not appear to be a relationship between the population estimates and the lower flows identified as optimum by the IFIM study. The number of days between May 15 and July 15 with flow less than 2000 cfs (Fig. 23) as an independent variable had a poor r^2 value of .21. Similarly, the number of days of flow less than 1000 cfs between May 15 and July 15 did not relate well with juvenile chinook salmon abundance (Fig. 22; r^2 value of .24). June has been considered a key rearing month for pre-smolt and smolt juvenile chinook salmon in the North Lewis River, although the number of June days with flow less than 2000 cfs does not relate well to juvenile abundance (r^2 value of .06).

Several relationships suggest that higher flows correlated with higher juvenile chinook salmon abundance. The relationship between total flow during the bulk of the rearing period (May-July) has a positive slope (Figure 7) and an r^2 value of .75. Total flow in June and July relates positively with pre-smolt abundance (Fig.6; r^2 value of .66). Average flow during June 16-30 also relates positively to juvenile chinook salmon abundance (Fig. 9; r^2 value of .55).

Specific categorizations of higher flow conditions resulted in the best correlation to juvenile chinook salmon abundance of the relationships examined, all with positive slopes. As independent variables, number of days from May 15 - July 15 with flow greater than or equal to 2600 cfs had an r^2 value of .60 (Fig. 24) and number of days greater than or equal to 3000 cfs had an r^2 value of .80 (Fig. 25). The number of days with flow between 3000-5000 cfs during April 15-June 30 had an r^2 value of .85 (Fig. 14). Number of contiguous days with flow greater than or equal to 2600 cfs beginning May 15 had an r^2 value of .94 (Fig. 11).

The best single factor correlation examined was a positive relationship with flows greater than or equal to 3000 cfs in May and June and 2000 cfs in July, excluding days during that period with flows greater than 7000 cfs as the independent variable (Fig. 20; r^2 value of .99). This relationship maintained an r^2 value of .93 when the days with flow greater than or equal to 7000 cfs were included (Fig. 16).

A total of 18 multiple regressions produced various results. The best relationships also incorporated flows greater than or equal to 3000 cfs in May and June and 2000 cfs in July, with r^2 values of .85 and .91 (Table 9).

DISCUSSION

The population estimate method chosen for this analysis utilizes adult returns to the spawning ground. However, the method maintains the ability to form juvenile chinook rearing population estimates independent of variables between the rearing and spawning stages. Annual variance in harvests by United States and Canadian troll and sport fleets in the ocean, gillnet and sport fisheries in the mainstem of the Columbia River, and the North Lewis River sport fishery, and variable ocean environmental conditions (such as the El Nino event of 1983) need not be considered when comparing annual juvenile chinook population estimates. The methodology assumes that tagged and non-tagged fish are subjected to the same conditions from emmigration as juveniles to return as adults. Therefore, a lower adult spawning return that is caused by an unusually high harvest rate will be equally compensated, in statistical application, by a lower survival rate reflected in tag recoveries. An analytical ability to disregard outside variables reduces the potential for error when making annual comparisons.

Statistical variability in the juvenile fall chinook population estimates and in this analysis should be considered when evaluating the strengths of apparent relationships with river flow. No variance estimate can be calculated about a single year juvenile estimate, due to the nature of the spawning populations estimate (McIsaac, 1987). Between year variability can be attributed to any differences in the CWT application process and statistical differences between preliminary and final values. It is assumed that annual variability is unbiased and relatively the same for each estimate; spawning ground estimation error is random (Norman, 1985b). Between year statistical variance is addressed below.

FIG 17. NFL FLOW VS POPULATION ESTIMATE

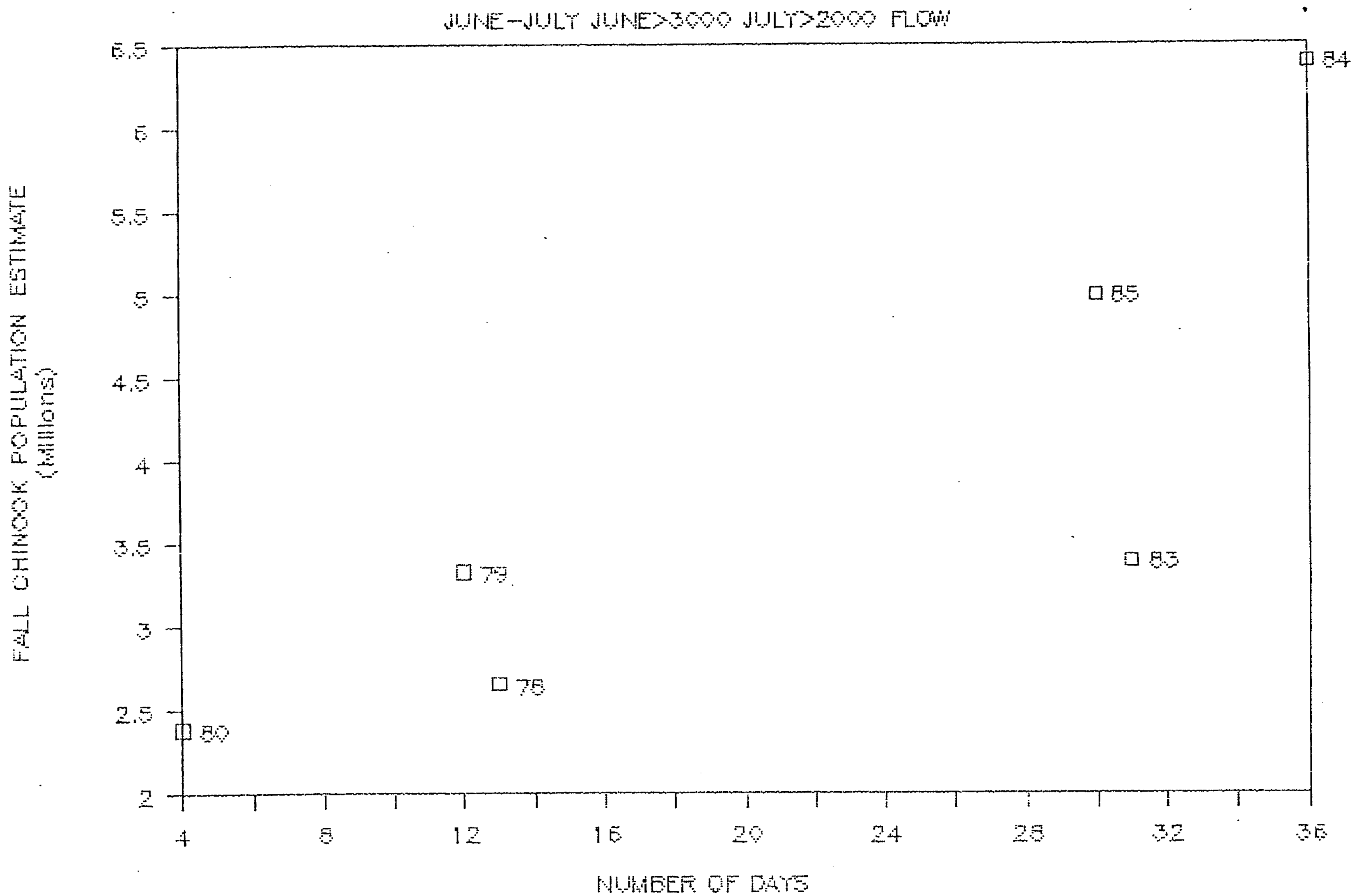

FIG 18. NFL FLOW VS POPULATION ESTIMATE

MAY-JULY MAY>4K JUNE>3K JULY>2K FLOW

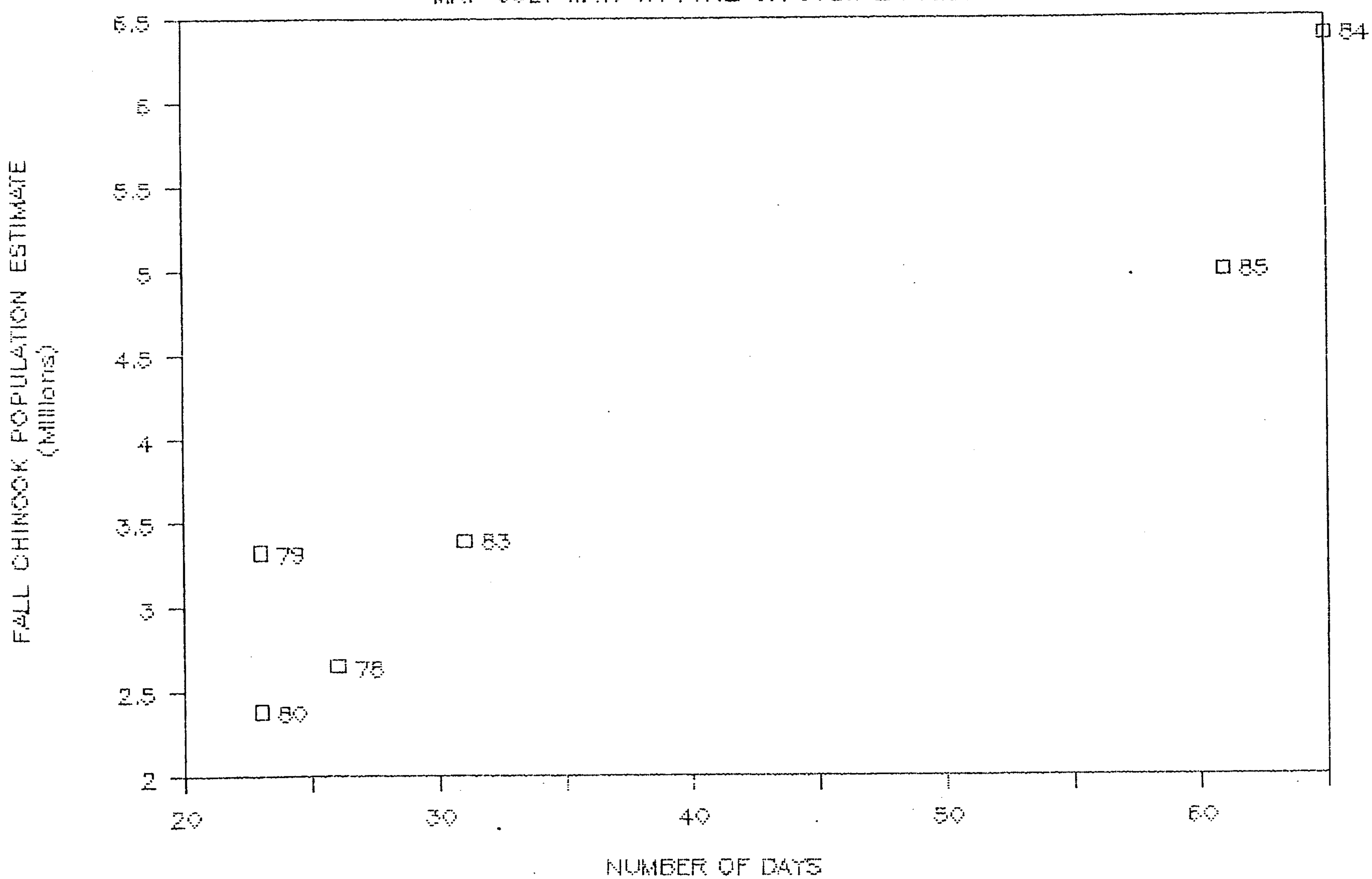

FIG 19. NFL FLOW VS POPULATION ESTIMATE

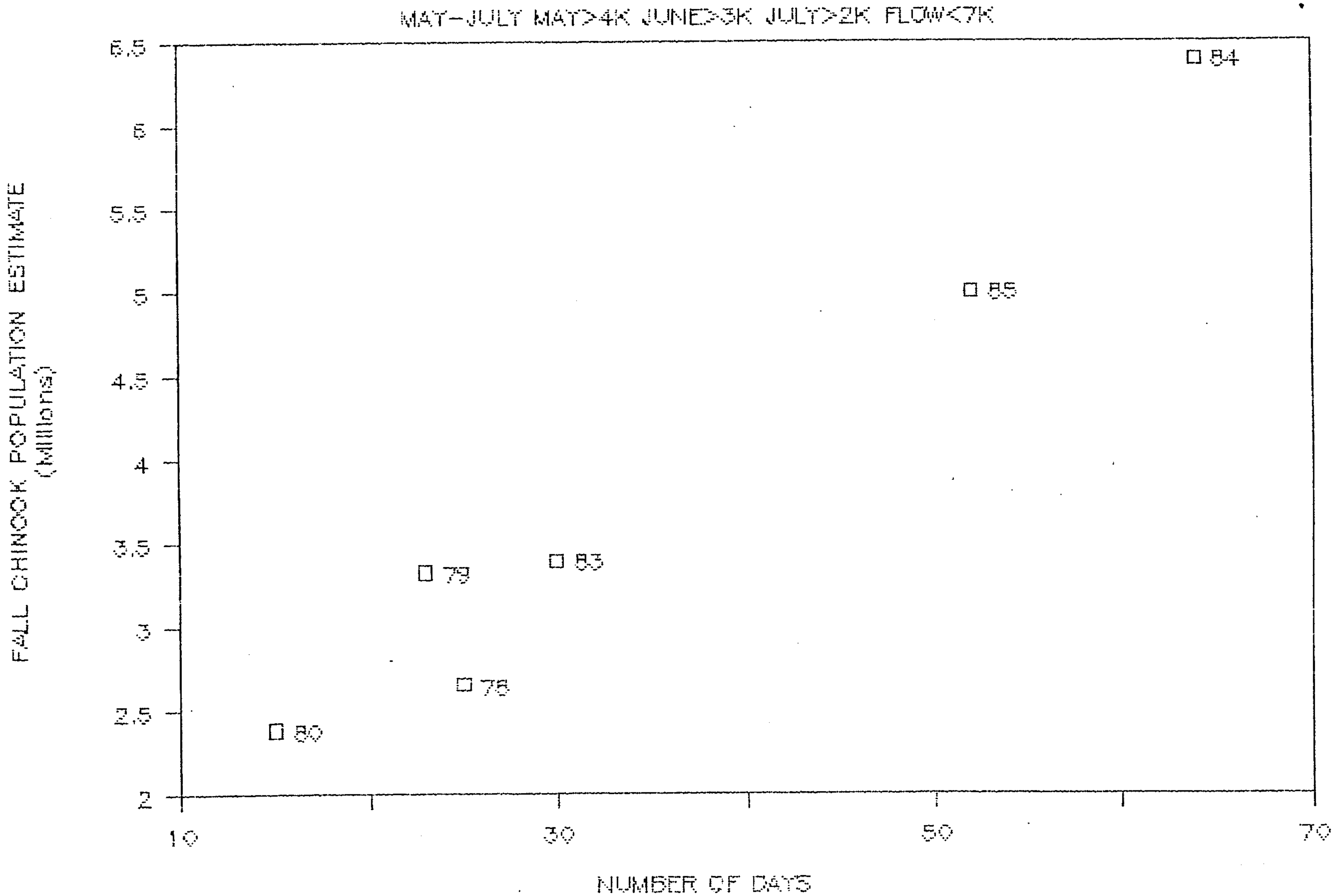

FIG 21. NFL FLOW VS POPULATION ESTIMATE

MAY>3K JUNE>3K<7K JULY>2K<7K FLOW

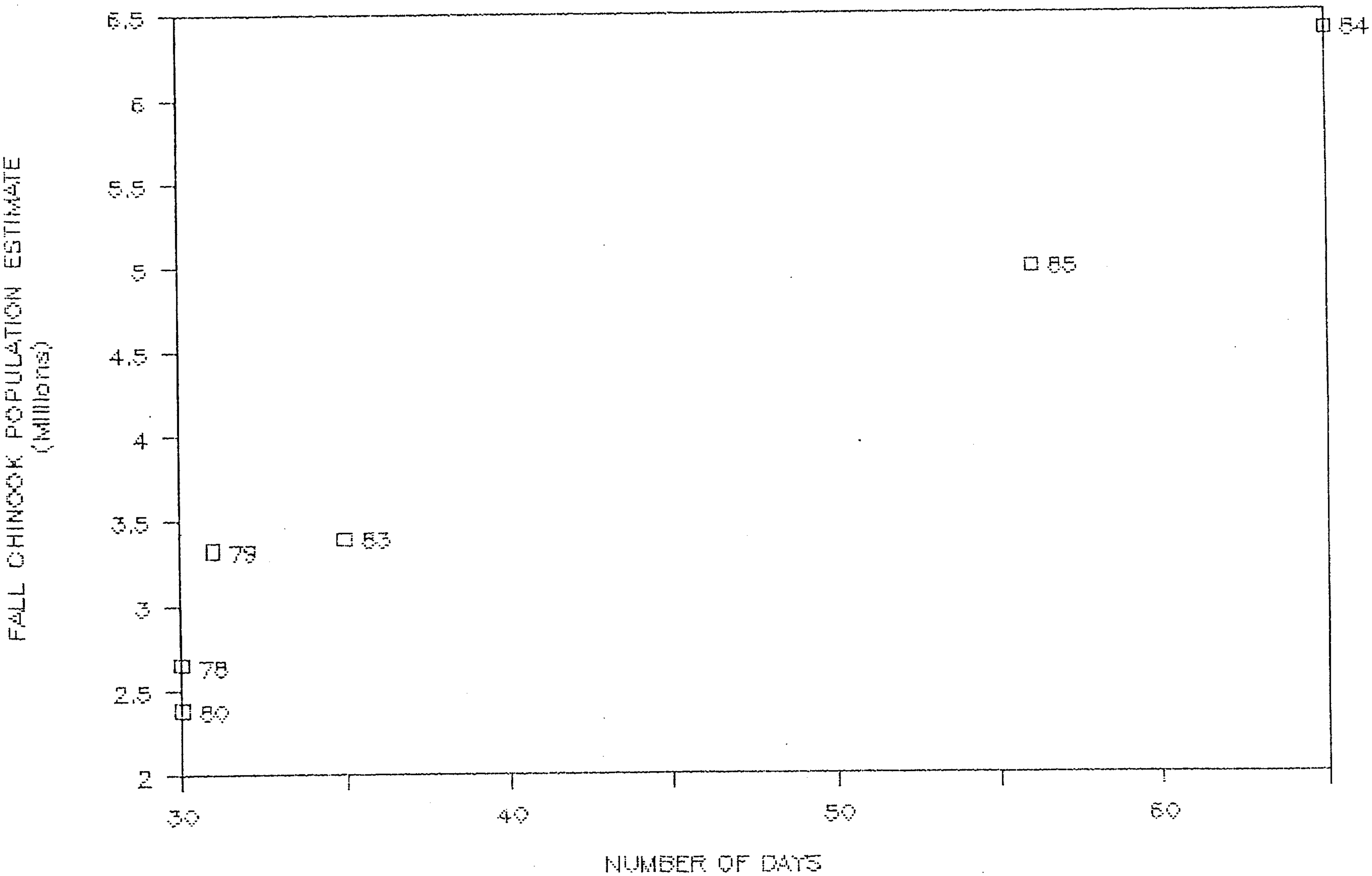

FIG 20. NFL FLOW VS POPULATION ESTIMATE

MAY-JULY MAY-JUNE>3K JULY>2K FLOW<7K